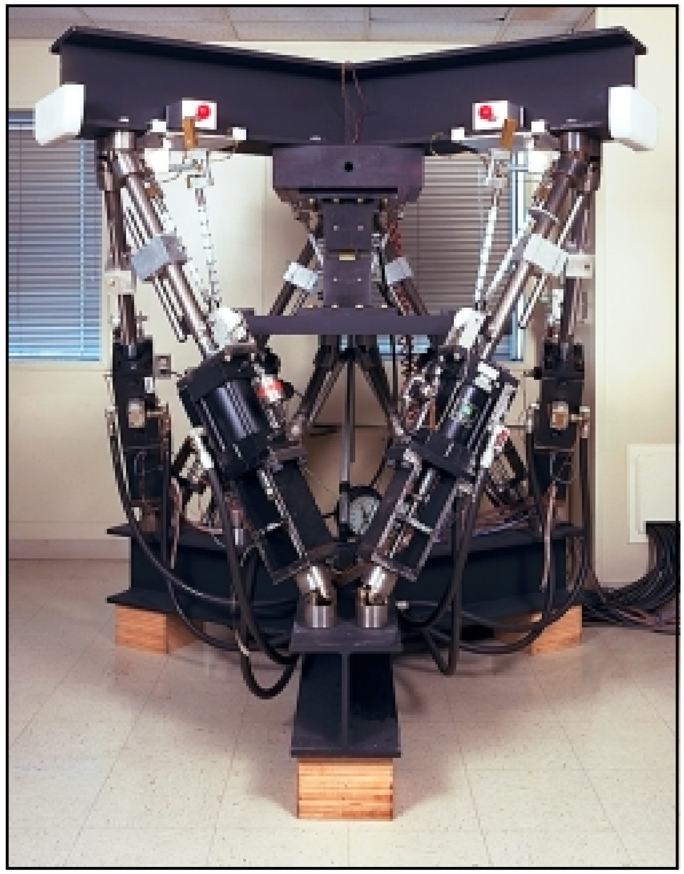
Computer-Controlled Universal Material Test System



Computer-Controlled Universal Material Test System

FUNCTION: Determines material properties and the structural response of components under a wide variety of loading conditions and temperatures by using computer-controlled servohydraulic load frames.

INSTRUMENTATION: The system is equipped with a 12-channel A/D module to monitor the response of the test specimen. A data acquisition system is also interfaced with the computer to support temperature measurements and additional A/D channels. Also, a Digital MINC-23 modular instrument computer is available for data collection independent of that contained in the control system. This computer can be configured by adding various modules to support a wide variety of data collection and manipulation.

DESCRIPTION: The system consists of a Micro PDP 11/23 with 512 KB of memory interfaced to a 12-channel A/D module, a 4-channel D/A module, and a test machine interface unit. These modules allow the computer to monitor test conditions and make control decisions depending on the test programming. Also, the response of the test specimen is recorded at the same time on an 11 MB hard disk. This system can operate any servohydraulic load frame and allows complicated and difficult material or component tests to be automated for greater accuracy and efficiency.

Various capacity load frames are available for testing compression, laser vulnerability, particle beam vulnerability, and for general materials and component testing.

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Materials Processing Facility

Materials Processing Facility

FUNCTION: Provides a full spectrum capability to synthesize and process materials, from small to large sizes, by a variety of methods and under varying thermal, mechanical, pressure, and rate-sensitive processes.

INSTRUMENTATION: Many of the facilities are modified versions of commercially purchased apparatus that have been adapted to the special needs of our research.

DESCRIPTION: Fully instrumented materials processing capabilities include facilities for powder production by fluid atomization, thermal evaporation, and arc erosion. These facilities offer the potential to create small particle sizes from 10 nm to 50 mm. The powder synthesis capabilities include a physical vapor deposition system designed to produce and coat submicron powders, in-situ. Facilities to process powder into bulk specimens by hot and cold isostatic pressing permit a variety of consolidation possibilities. Isothermal heat treatment facility and quenching dilatometer permit accurate determinations of phase relationships in metals. Arc melting facilities permit alloy synthesis and single crystal growth. Bulk alloys can by prepared by induction melting, while rapidly solidified metals of thin cross section can be made by splat quenching and melt spinning. The facility includes rolling mills, swagers, and wire-drawing facilities. Metal-matrix composites and surface coatings are produced in a variety of computer-controlled, physical vapor deposition systems for coating fibers and surfaces. Ceramic and ceramic-matrix composites processing facilities include a wide variety of conventional, controlled atmospheric furnaces, hot presses, ball milling apparatus and particle size determination, and sol-gel and organometallic coating processing capabilities.

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Mechanical and Thermal Experimental Facilities

Mechanical and Thermal Experimental Facilities

FUNCTION: Determines material behavior under cyclic, static, and complex loading conditions from ambient to high temperatures simulating the load-environmental conditions representative of service.

INSTRUMENTATION: Several of the facilities, such as creep units and special accessories, are designed and fabricated at NRL. Other facilities are purchased commercially and are modified for the advanced needs of the scientists.

DESCRIPTION: There are a number of computer-controlled, automated, servo-hydraulic mechanical testing systems, creep testing machines, high-temperature tensile and fracture toughness testing machines with controlled environmental chambers to provide either inert or regulated environments for material characterization under representative service loads and environments. Automation includes programmable feedback control systems that can simulate service spectral loads with data acquisition for simulating and characterizing the material response under complex loading conditions. Other automated systems include a multiaxial testing machine with six degrees of freedom that can determine static and dynamic properties. The facilities include systems that can apply thermal, thermomechanical, and electromechanical cyclic loads, vacuum chambers, and noncontact laser extensometers that can accurately determine material responses to temperatures up to 1500 °C. In addition, several specially made high temperature loading devices and accessories required for testing complex specimen geometries are included in the facilities.

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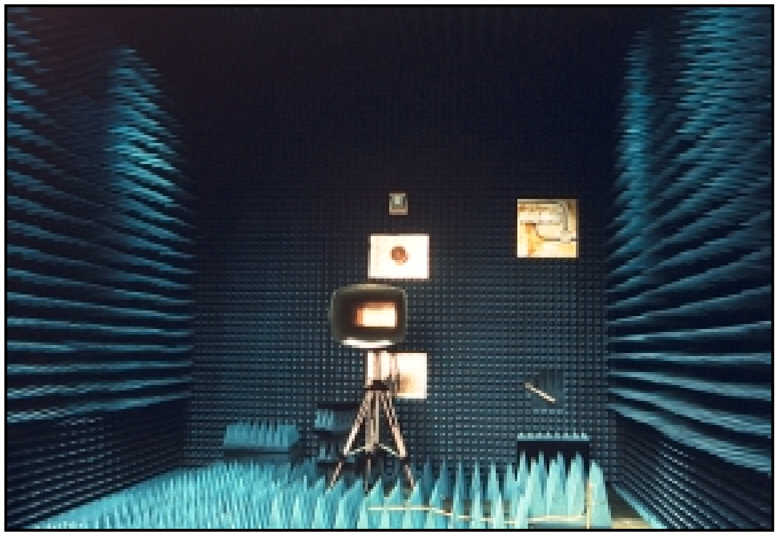
High-Power Microwave (HPM) Facility



High-Power Microwave (HPM) Facility

FUNCTION: Provides a state-of-the-art capability to investigate the response of systems, components, and materials to HPM radiation. Narrowband pulsed and continuous wave (CW) experiments, as well as wideband pulsed experiments, can be carried out at frequencies ranging from 0.5 to 94.0 GHz. The facility is equipped to do coupling cross-section measurements, free-field irradiation experiments on systems and components, and plasma-mediated coupling investigations of materials.

INSTRUMENTATION: The microwave sources include several high-power (1 MW peak) tunable pulsed magnetrons with frequencies ranging from 2.6 to 35.0 GHz, low-power traveling wave tubes operating from 0.5 to 8.0 GHz, 35.0 and 94.0 GHz gyrotrons (100 kW peak), and a Bournlea wideband pulser. Various standard and wideband horns are available for irradiation experiments in the anechoic chamber. A 16-channel digital data-acquisition system is used to record the response data. Scalar and vector network analyzers and an HP antenna measurement system provide the necessary support for calibration and field measurements.

DESCRIPTION: The facility is composed of four separate rooms or chambers that are approved for classified work. A large anechoic chamber (4.9 × 4.9 × 9.8 m long), with an access doorway 2.4 m wide × 3.7 m high, permits full system testing of, for example, antiship cruise missiles. Systems and other test objects are placed in the anechoic chamber and instrumented to record their functional responses in the presence of a microwave field. Various sources of microwave radiation are housed in a source room adjacent to the anechoic chamber, and the radiation is fed into the chamber through ports in the common wall. Fiber-optic telemetering of the system / material response functions is accomplished by bringing the test-object cables through the chamber floor along a trough to a control screen room where data acquisition equipment is located. Finally, a large vault room (4.9 m wide × 3.0 m high × 14.6 m long) serves as a laboratory for preparing the systems / test objects for experiments and for conducting injection, transfer-function, and other measurements.

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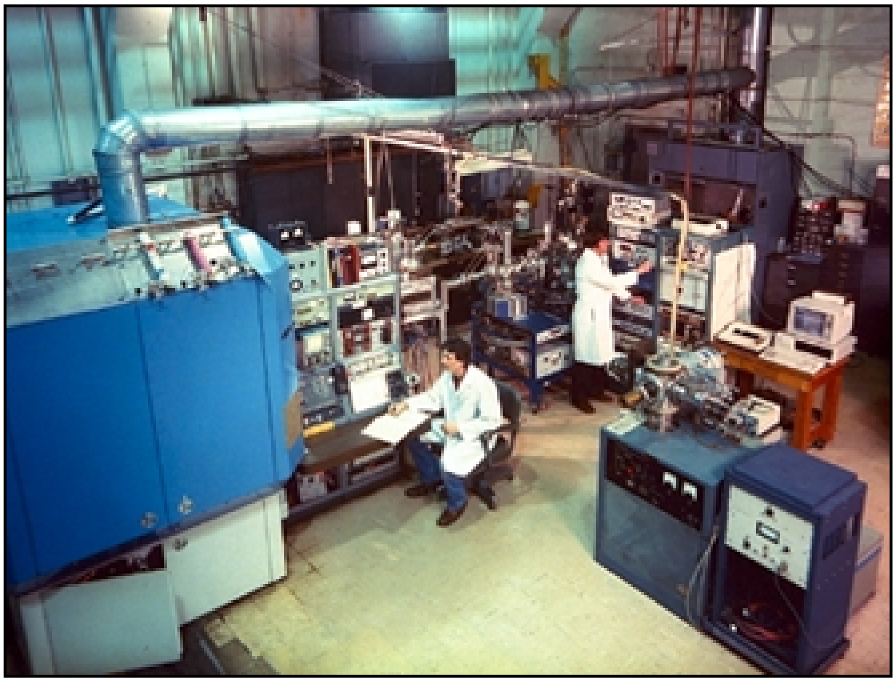
Ion Implantation Facility



Ion Implantation Facility

FUNCTION: Modifies the surface properties of materials by bombardment with energetic ions of any elemental species. Modifications include doping and patterning of semiconductors, surface alloys that protect against wear and corrosion, formation of metastable materials, and changes on the optical constants.

INSTRUMENTATION: Varian/Exrion Model 200A2F ion implanter with 10^{-7} Torr vacuum in standard chamber; UHV chamber with 10^{-9} Torr vacuum equipped with cylindrical mirror Auger electron analyzer and coaxial 5 keV electron gun, a 5 keV sputter ion gun with rastering, and a 1 keV Kaufman ion gun for ion beam sputter deposition; a high-vacuum target chamber with a 3 kW electron beam evaporator and quartz crystal evaporation rate controller; a high vacuum chamber that includes an oven for heating liquids and a cryogenically cooled sample holder.

DESCRIPTION: The heart of this facility is a 200 kV ion implanter modified to produce intense ion beams of virtually any element in the periodic table. The standard target vacuum chamber is cryogenically pumped and equipped with a rotating water-cooled feedthrough to implant cylindrical geometry specimens up to 25 cm in diameter, a cryogenic feedthrough to cool samples down to 77 K, and a hot stage to warm samples up to 700 °C. Three other mobile target chambers can be attached to the rear of the standard target chamber. The first chamber is an Auger analyzer-equipped, ultrahigh-vacuum chamber for implantation in an ultraclean environment and for in situ sputter-Auger analysis of implanted surfaces. The second chamber is equipped with an electron beam evaporator that allows for simultaneous ion bombardment and deposition of thin films (ion-beam-assisted deposition) under computer control. The third chamber is equipped to allow relatively high gas pressures to perform ion-beam-induced chemical vapor deposition of thin films on substrates near room temperature.

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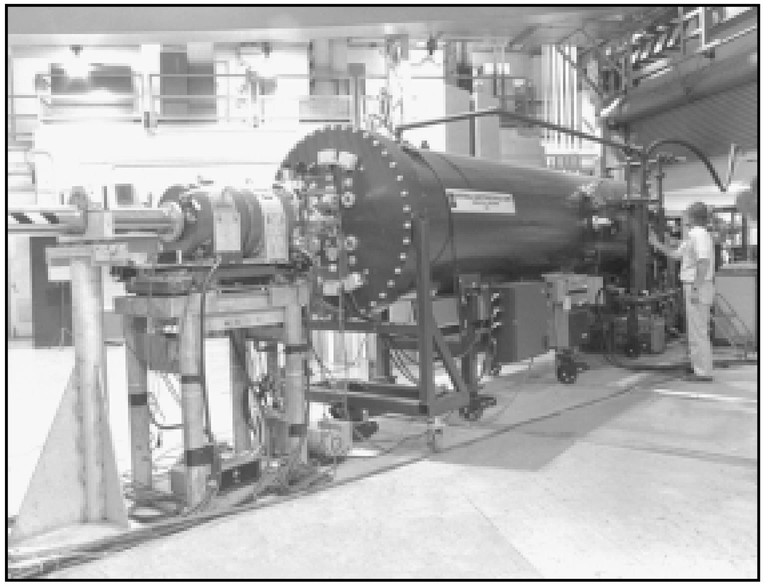
3-MV Tandem Van de Graaff Accelerator



3-MV Tandem Van de Graaff Accelerator

FUNCTION: Provides a source of high-energy ions for near-surface analysis, high-energy implantation, and radiation effects studies.

INSTRUMENTATION: There are three beam lines: (1) an analysis beam line with a variable angle Si particle detector for Rutherford backscattering and elastic recoil detection, an Si(Li) detector for particle-induced X rays, manual and computer controlled goniometers for ion channeling, NaI and Ge(Li) detectors for gamma ray detection, and a 0.02 steradian acceptance solid angle, double focusing, 180° magnetic spectrometer with 0.2% energy resolution; (2) a high-energy ion implantation beam line for uniform implantation over a 4-in. diameter wafer, with heating, and water or liquid nitrogen cooling of the sample; and (3) a small deflection angle beam line for high energy, magnetically rigid heavy ions equipped with a microbeam for spatially resolved studies of radiation effects in devices, with a sampling oscilloscope with 70 GHz bandwidth, and a port for calibration of radiation or particle detectors. All beam lines have cryopumps or turbopumps for clean vacuum conditions.

DESCRIPTION: The 3-MV Tandem Van de Graaff is a model 9SDH-2 Pelletron built by National Electrostatics Corporation. A terminal voltage of 3 MV is generated by 2 “pelletron” charging chains capable of carrying a 300 μA current. Negative ions are injected at 20 to 60 kV and are accelerated to the terminal. Electrons are then stripped from the negative ions by collisions with a stripper gas or carbon stripping foils, and the resultant positive ions are then repelled by the terminal potential to ground. Beam energies attainable depend upon the charge state of the ion and the terminal voltage V, i.e., $E = V(1+i)$, where i is the positive charge on the stripped ion. Thus, protons can be accelerated to 6 MeV, alpha particles to 9 MeV, and highly stripped Au nuclei (+12) to 39 MeV. The lower limit of beam energy is about 400 keV. An RF ion source for gases ionizes hydrogen or helium to produce positive ions and then converts about 2% of them to negative ions by charge exchange in an Rb vapor canal. Beam currents of 12.5 μA for protons and 2 μA for alphas are routine. A cesium ion sputtering source is used to produce negative ion beams of solid elements with beam currents in the nA to 30 μA range.

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